The Chemical Compositions and Habitability of Terrestrial Planets in the Universe

Charles H. Lineweaver
Planetary Science Institute
Research School of Astronomy and Astrophysics
Research School of Earth Sciences
Australian National University
Canberra, ACT,
AUSTRALIA
charley@mso.anu.edu.aux

The collapse of molecular clouds into stars, protoplanetary disks and eventually habitable worlds is a universal process that involves a series of fractionation events. Hydrogen, helium and other volatiles are removed leaving the more refractory elements. The refractory elements are then further fractionated by condensation sequences and mixed by turbulence. This fractionation and mixing can be constrained by measurements of the dispersions of elemental abundances in stars, meteorites and by estimates of the elemental abundances in the terrestrial planets of our Solar System. These constraints yield our best estimates of the chemical compositions of terrestrial planets in the universe. Focusing in on habitability, the NASA injunction to "follow the water" is equivalent to finding environments in which pressures and temperatures are compatible with liquid water. Just as the dispersion of the relative elemental abundances provides a more useful estimate of what to expect elsewhere, than any single body can -- a pressure-temperature phase diagram of the broadly terrestrial bodies of our Solar System can be used to estimate the range of environments and habitability of terrestrial planets elsewhere in the universe. On a P-T phase diagram, we quantify the broad area occupied by the various terrestrial planets and moons of our Solar System and we argue that this broad area may be a robust feature of extrasolar terrestrial environments